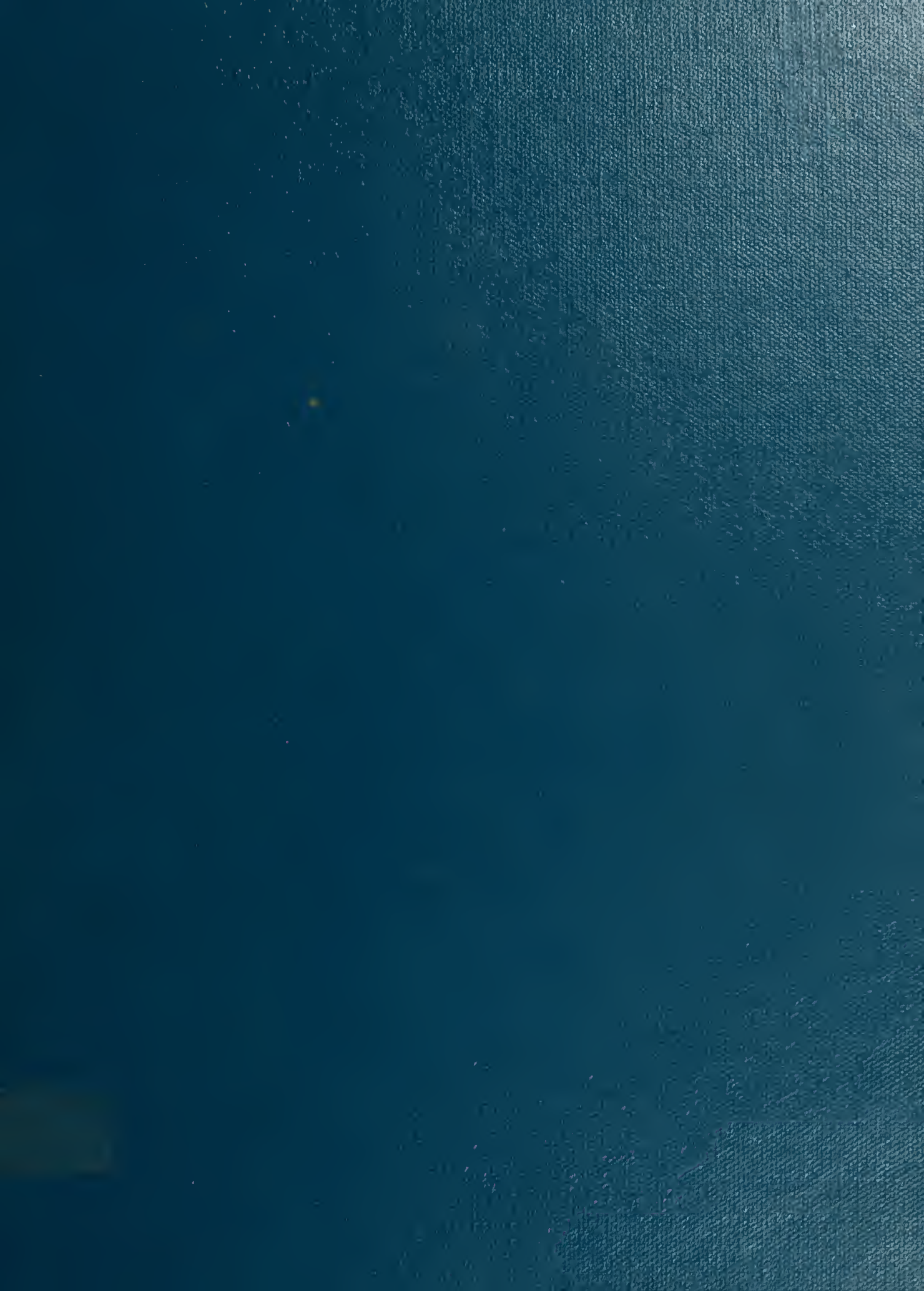

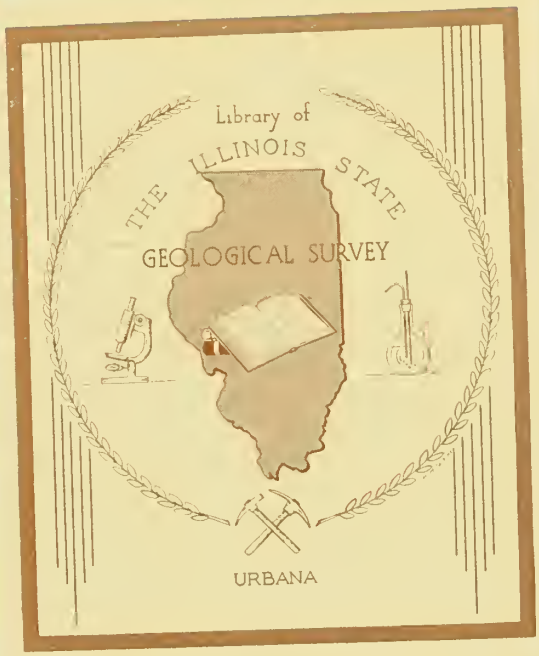

ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief Urbana, Illinois
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INDUSTRIAL MINERALS NOTES NO. 28

ILLINOIS CLAYS AS BINDERS FOR IRON ORE PELLETS— A FURTHER STUDY

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ABSTRACT

Clays from 13 areas in 10 counties of Illinois, from the northern border to the Ohio River and from the east-central area to the Mississippi River, were tested to determine their value as binding agents for the growing iron ore pelletizing industry.

Some of the Illinois clays treated with soda ash make binders that show excellent possibilities of being commercially acceptable. Iron ore pellets containing these clays develop green strength and fired strength as high as those of pellets made with the universally accepted western bentonites. Dry strength is not as high as when bentonite is used as a binder, but sufficiently high to be acceptable for most applications.

ILLINOIS CLAYS AS BINDERS FOR IRON ORE PELLETS— A FURTHER STUDY

INTRODUCTION

The pelletizing of iron ore in the United States, which started in the 1950's, is growing at an impressive rate. Annual domestic capacity is 33,500,000 tons, facilities with a 15,950,000-ton capacity are under construction, and an additional 3,750,000-ton annual production is indicated at "potential" (planned) pellet plants.* When plants now in operation are augmented by those under construction, 49,450,000 tons of pellets will be produced annually. As each ton will contain from 13 to 16 pounds of binder, 300,000 to 400,000 tons of binder will be needed each year.

In April 1965, the Illinois State Geological Survey published Industrial Minerals Notes 22, "Illinois Clays as Binders for Iron Ore Pellets," which reported that certain Illinois clays, properly prepared, could be used in making pellets, arousing the interest of Illinois producers of montmorillonite clays and of iron ore producers in nearby states.

This study was made to determine whether additional Illinois clays, located reasonably close to iron mines, had bonding characteristics good enough to make them attractive substitutes for western bentonites.

CLAYS TESTED

Twelve samples of accretion-gley (clay deposits formed on the surface of glacial till) from 11 areas in 8 counties, one sample of underclay from a coal area in southwestern Illinois, one sample from Pulaski County which was the most promising clay from the previous report, and one sample of the generally accepted bentonite were tested. The source areas of the samples tested in the reports are shown in figure 1, and table 1 gives the sample locations and general geologic and mineralogic information. The new samples came from Effingham, Montgomery, Sangamon, Adams, Pike, Fulton, Ogle, Stephenson, and St. Clair Counties.

The clay from Pulaski County and the bentonite were retested to serve as a basis of comparison for the other clays. The Pulaski County clay has shown adaptability in plant tests and the bentonite is accepted by the pelletizing industry. Too, there is such a wide difference in reporting the green, dry, and fired strengths of pellets that they provided a better comparison of results than ounces and pounds alone.

*Iron Ore-News Highlights of 1965, American Iron Ore Association, Cleveland, Ohio.

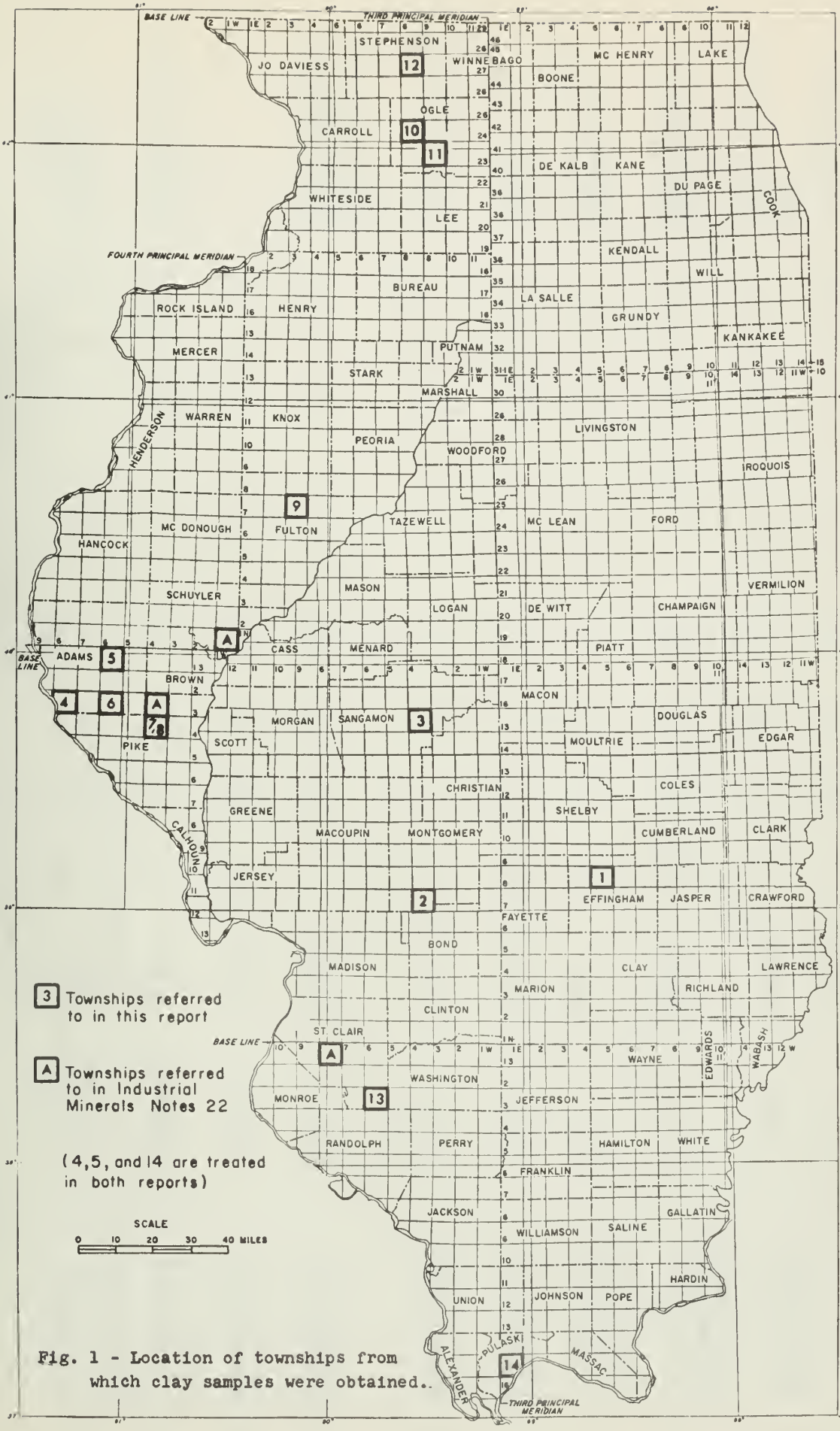

Fig. 1 - Location of townships from which clay samples were obtained..

TABLE 1 - CLAY MATERIALS TESTED

	Clay sample	County	Location				Thickness (ft.)		Relative defraction intensities of clay minerals (%)				Remarks
			Quarter	Sec.	T.	R.	Over-burden	Clay	K	I	M	Mx	
1.	Accretion-gley Funkhouser East sec.	Effingham	SE SW (North side of U.S. 40)	34	8N	5E	5	4	7	0	61	32	4' channel
2.	Accretion-gley Panama "A" sec.	Montgomery	SW SW SE	23	7N	4W	2	4	3	6	66	25	Overburden is loess and gleyed loess
3.	Accretion-gley Rochester sec.	Sangamon	NW SE NW	34	15N	4W	10	5	4	8	55	31	
4.	Accretion-gley Zion Church sec.	Adams	SE SE SW	9	3S	8W	10-25	10	11	17	43	29	Sangamon accretion-gley, Loveland Silt, Yarmouth accretion-gley
5.	Accretion-gley Lierle Creek sec.	Adams	SE cor. SW	33	1S	6W	8	8	8	4	61	27	Sangamon and Yarmouth accretion-gleys
6.	Accretion-gley Akers School sec.	Adams	NE NE NE	11	3S	6W	8-20	5	11	0	61	28	5' channel sample Sandy clay
7.	Accretion-gley Woodland School sec. (lower sample)	Pike	SW NE	29	4S	4W	15	3	6	10	69	17	Unweathered Baylis Fm. (Cretaceous) 3'
8.	Accretion-gley Woodland School sec. (upper sample)	Pike	SW NE	29	4S	4W	11	4	10	0	53	37	Weathered Cretaceous below loess
9.	Accretion-gley Hipple School	Fulton	NW SW SW	8	7N	3E	8	4	7	11	55	27	Sangamon accretion-gley
10.	Accretion-gley Forreston sec.	Ogle	NW SW NE	2	24N	8E	2-10	5	3	9	65	23	On Winnebago Till

TABLE 1 - (Continued)

Clay sample	County	Location				Thickness (ft.)		Relative defraction intensities of clay minerals (%)				Remarks
		Quarter	Sec.	T.	R.	Over-burden	Clay	K	I	M	Mx	
11. Accretion-gley Mt. Morris sec.	Ogle	NE cor.	2	23N	9E	2	5+	7	28	52	13	Accretion-gley on Winnebago Till
12. Accretion-gley Cedarville East sec.	Stephenson	NE cor.	4	27N	8E	2	3	7	0	31	62	Accretion-gley on Winnebago Till
13. Underclay below No. 6 Coal River King Mine	St. Clair	SE NE SE	20	3S	6W	50	5	9	44	0	47	Underclay
14. Porters Creek Olmsted	Pulaski	NE SE	27	15S	1E	20-40	20	3	9	78	10	
15. Western bentonite	State of Wyoming							0	0	99	1	Commercial product

K = Kaolinite constituents
I = Illite constituents
M = Montmorillonite constituents
Mx = Mixed layers, mostly expandable

SAMPLE PREPARATION

The raw clay samples were air dried to about 8 percent moisture, crushed in a laboratory jaw crusher set at an opening of a quarter of an inch, and screened on a 3-mesh sieve, with the oversize passed through crushing rolls set at slightly less than 3 mesh. The material was kept in closed circuit until all of it had passed through that screen.

The screened samples were mixed by standard coning and quartering, after which representative 5-kilogram samples were taken for further work. These were dried for 24 hours at 224° F (107° C) in a laboratory drier with controlled heat.

One kilogram of each of the clays was taken for size analysis of its individual grains. Each of these samples was subjected to 30 minutes of wet attrition, during which the agglomerates but not the individual grains were broken up. After attrition, the pulp (clay and water) was passed through a 325-mesh (44-micron) screen. Both the sand and slime fractions were dried. The sand was sized on conventional 35- to 325-mesh screens. The minus-325-mesh cake of each of 15 samples was sized in a Roller Particle Size Analyzer. The coarse material had already been removed from the Pulaski County clay and bentonite. Complete as-received size analyses appear in table 2.

TABLE 2 - SIZE ANALYSES OF CLAY SAMPLES AS RECEIVED

Sample	1		2		3		4		5	
County	Effingham		Montgomery		Sangamon		Adams		Adams	
Section	Funkhouser E.		Panama "A"		Rochester		Zion Church		Lierle Creek	
	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.
+35 mesh	4.04	4.04	4.64	4.64	2.98	2.98	5.62	5.62	1.28	1.28
+48 mesh	6.93	10.97	6.69	11.33	3.01	5.99	6.60	12.22	3.70	4.98
+65 mesh	4.38	15.35	5.94	17.27	2.99	8.98	5.76	17.98	3.37	8.35
+100 mesh	2.78	18.13	4.09	21.36	3.64	12.62	4.51	22.49	2.78	11.13
+150 mesh	1.70	19.83	2.70	24.06	4.16	16.78	3.31	25.80	2.00	13.13
+200 mesh	1.70	21.53	2.48	26.54	5.85	22.63	3.44	29.24	2.15	15.28
+325 mesh	2.07	23.60	2.93	29.47	5.61	28.24	4.10	33.34	3.03	18.31
+40 micron	3.03	26.63	0.68	30.15	1.48	29.72	2.10	35.44	1.72	20.03
+30 micron	11.70	38.33	9.57	39.72	7.78	37.50	8.90	44.34	8.08	28.11
+20 micron	14.89	53.22	16.46	56.18	13.11	50.61	13.99	58.33	16.66	44.77
+10 micron	22.59	75.81	20.02	76.20	18.67	69.28	17.78	76.11	23.60	68.37
+5 micron	12.92	88.73	14.26	90.46	18.10	87.38	15.10	91.21	20.52	88.89
-5 micron	11.27		9.54		12.62		8.79		11.11	

(Continued on page 7)

TABLE 2 - (Continued)

Sample	6		7		8		9		10	
County	Adams		Pike		Pike		Fulton		Ogle	
Section	Akers School		Woodland School (lower sample)		Woodland School (upper sample)		Hipple School		Forreston	
	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.
+35 mesh	3.39	3.39	3.48	3.48	0.87	0.87	5.31	5.31	1.77	1.77
+48 mesh	5.85	9.24	5.08	8.56	1.87	2.74	6.31	11.62	3.20	4.97
+65 mesh	5.35	14.59	6.06	14.62	2.49	5.23	4.59	16.21	2.94	7.91
+100 mesh	4.10	18.69	3.78	18.40	2.13	7.36	3.36	19.57	2.57	10.48
+150 mesh	2.88	21.57	2.21	20.61	1.38	8.74	2.37	21.94	1.90	12.38
+200 mesh	3.17	24.74	1.99	22.60	1.39	10.13	2.50	24.44	2.00	14.38
+325 mesh	3.39	28.13	2.20	24.80	1.65	11.78	3.11	27.55	3.09	17.47
+40 micron	1.69	29.82	0.89	25.69	1.62	13.40	0.53	28.08	0.76	18.23
+30 micron	7.22	37.04	10.63	36.32	8.78	22.18	4.04	32.12	8.19	26.42
+20 micron	15.67	52.71	16.49	52.81	21.85	44.03	11.86	43.98	17.37	43.79
+10 micron	20.65	73.36	24.93	77.74	27.43	71.46	21.92	65.90	24.47	68.26
+5 micron	15.96	89.32	15.27	93.01	22.12	93.58	19.55	85.45	20.33	88.59
-5 micron	10.68		6.99		6.42		14.55		11.41	

Sample	11		12		13		14		15	
County	Ogle		Stephenson		St. Clair		Pulaski		State of Wyoming	
Section	Mt. Morris		Cedarville East		River King Mine		Olmsted		Unknown	
	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.	% wt.	Cuml. % wt.
+35 mesh	1.91	1.91	1.82	1.82	9.32	9.32	---	---	---	---
+48 mesh	4.08	5.99	5.49	7.31	1.39	10.71	---	---	---	---
+65 mesh	4.25	10.24	4.18	11.49	0.82	11.53	---	---	---	---
+100 mesh	4.18	14.42	2.89	14.38	0.93	12.46	---	---	---	---
+150 mesh	3.01	17.43	1.74	16.12	0.90	13.36	---	---	---	---
+200 mesh	2.85	20.28	1.57	17.69	1.39	14.75	---	---	---	---
+325 mesh	3.11	23.39	1.87	19.56	2.31	17.06	---	---	---	---
+40 micron	0.53	23.92	0.29	19.85	0.06	17.12	6.43*	6.43	20.46*	20.46
+30 micron	3.75	27.67	2.97	22.82	0.79	17.91	8.10	14.53	11.25	31.71
+20 micron	9.15	36.82	11.11	33.93	3.72	21.63	11.72	26.25	15.66	47.37
+10 micron	18.94	55.76	24.73	58.66	14.66	36.29	28.14	54.39	20.69	52.63
+5 micron	25.02	80.78	27.44	86.10	34.44	70.73	30.25	84.64	22.46	90.52
-5 micron	19.22		13.90		29.27		15.36		9.48	

*Clays 14 and 15 were prepared clays and only sub-sieve analyses were made on them.

TABLE 3 - SIZE ANALYSES OF CLAYS USED IN PELLETIZING
TEST SERIES A AND B

Sample	1	2	3	4	5	6	7
County	Effingham	Montgomery	Sangamon	Adams	Adams	Adams	Pike
Section	Funkhouser East	Panama "A"	Rochester	Zion Church	Lierle Creek	Akers School	Woodland (lower)
Tonnage factor*	1.309	1.418	1.394	1.500	1.224	1.391	1.330
	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.
+40 micron	3.96	0.96	2.06	3.15	2.11	2.35	1.19
-40 +30 micron	15.32	13.57	10.85	13.36	9.89	10.05	14.13
-30 +20 micron	19.48	23.34	18.26	20.99	20.39	21.81	21.92
-20 +10 micron	29.56	28.39	26.02	26.67	28.89	28.73	33.16
-10 +5 micron	16.91	20.22	25.23	22.66	25.12	22.20	20.30
-5 micron	14.77	13.52	17.58	13.17	13.60	14.86	9.30

Sample	8	9	10	11	12	13	14	15
County	Pike	Fulton	Ogle	Ogle	Stephenson	St. Clair	Pulaski	State of Wyoming
Section	Woodland (upper)	Hipple School	Forreston	Mt. Morris	Cedarville East	River King M.	Olmsted	Unknown
Tonnage factor*	1.134	1.380	1.212	1.305	1.243	1.206	**	**
	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.
+40 micron	1.84	0.73	0.92	0.69	0.36	0.07	6.43	20.46
-40 +30 micron	9.95	5.57	9.92	4.90	3.69	0.95	8.10	11.25
-30 +20 micron	24.77	16.38	21.04	11.95	13.81	4.49	11.72	15.66
-20 +10 micron	31.09	30.26	29.65	24.72	30.74	17.67	28.14	20.69
-10 +5 micron	25.08	26.98	24.63	32.66	34.11	41.53	30.25	22.46
-5 micron	7.27	20.08	13.84	25.08	17.29	35.29	15.36	9.48

* Tonnage factor is the number of tons of dry raw clay needed to produce one ton of quality clay.

** Samples 14 and 15 were delivered to the Survey's laboratories as finished products and no tonnage figures are available.

LABORATORY TESTS

Green strength, dry strength, and fired strength were the three main properties considered in the laboratory tests. The green strength is of considerable importance in commercial practice as it is the property that holds the pellet together when it is moved from the balling device to the furnace. The dry strength supports the burden during the transition from wet to fired conditions. This is important in the travelling grate furnaces, and in the shaft furnaces used at some plants it is the most important single criterion in selecting binding agents. The fired strength must be sufficient to keep the pellet together during cooling, stockpiling, loading, and all subsequent handling.

Industrial Minerals Notes 22 showed that the finer the clay, the stronger the pellets that could be made with it. After that report was

TABLE 4 - SIZE ANALYSES OF CLAYS USED IN PELLETIZING
TEST SERIES C

Sample	1	2	3	4	5	6	7
County	Effingham	Montgomery	Sangamon	Adams	Adams	Adams	Pike
Section	Funkhouser East	Panama "A"	Rochester	Zion Church	Lierle Creek	Akers School	Woodland (lower)
Tonnage factor*	2.138	2.282	2.025	2.400	1.811	2.115	2.119
	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.
-20 +10 micron	48.27	45.70	37.80	42.67	42.73	43.67	52.83
-10 +5 micron	27.62	32.55	36.65	36.25	37.15	33.75	32.35
+5 micron	24.11	21.75	25.55	21.08	20.12	22.58	14.82

Sample	8	9	10	11	12	13	14	15
County	Pike	Fulton	Ogle	Ogle	Stephenson	St. Clair	Pulaski	State of Wyoming
Section	Woodland (upper)	Hipple School	Forreston	Mt. Morris	Cedarville East	River King M.	Olmsted	Unknown
Tonnage factor*	1.787	1.785	1.779	1.583	1.514	1.276	**	**
	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.	% wt.
-20 +10 micron	49.00	39.14	43.53	29.98	37.43	18.70	38.16	39.31
-10 +5 micron	39.52	34.90	36.17	39.60	41.53	43.95	41.02	42.68
-5 micron	11.48	25.96	20.30	30.42	21.04	37.35	20.82	18.01

* Tonnage factor in this usage is defined as the number of tons of dry raw clay needed to produce one ton of this quality clay.

** Samples 14 and 15 were delivered to the Survey's laboratories as finished products and no tonnage figures are available.

published, a small amount of sodium carbonate was found to increase the binder strength markedly. Whether this is a sodium replacement on the calcium montmorillonite or whether it is the result of the dispersing action of the sodium carbonate has not been determined and is beyond the scope of this paper.

As an average of 16 pounds of clay per ton of iron ore is an accepted standard in the industry, three batches of pellets were made from each clay in the following proportions:

Series A — 16 pounds of minus-325-mesh clay per ton of iron concentrate
Series B — 16 pounds of minus-325-mesh clay and 2 pounds of soda ash (sodium carbonate) per ton of iron concentrate
Series C — 16 pounds of minus-20-micron clay per ton of iron concentrate.

The size analyses of the clays used appear in tables 3 and 4.

The binders and the clay were intimately mixed, put into the pelletizing wheel, and wetted with a quantity of water to make desirable pellets.

TABLE 5 - TEST RESULTS OF PELLETS MADE WITH IRON ORE CONCENTRATE AND CLAY FOR SERIES A
(16 pounds of minus-325-mesh clay per ton of iron ore concentrate)

Sample	County	Section	Moisture (%)	Drops to failure	Green strength (oz.)		Dry strength (lbs.)		Fired strength (lbs.)	
					Av.	Extremes	Av.	Extremes	Av.	Extremes
1	Effingham	Funkhouser East	4.8	2.3	12.8	11.0-14.0	1.9	1.4-2.4	1372	1041-1531
2	Montgomery	Panama "A"	7.0	2.0	13.1	10.5-16.0	1.0	0.7-1.4	1430	1286-1531
3	Sangamon	Rochester	5.6	2.0	17.0	11.0-22.0	2.4	1.9-2.9	1496	1348-1531
4	Adams	Zion Church	5.7	2.0	12.3	10.0-14.5	3.0	2.5-3.1	1201	1140-1531
5	Adams	Lierle Creek	6.4	1.9	15.0	10.0-21.0	3.2	2.0-5.1	1404	1072-1531
6	Adams	Akers School	6.5	1.7	12.5	7.0-23.0	2.9	2.0-3.5	1289	735-1531
7	Pike	Woodland (lower)	6.2	2.0	9.5	6.0-15.0	0.8	0.6-1.2	922	368-1225
8	Pike	Woodland (upper)	5.2	2.0	11.7	9.0-15.0	1.8	1.1-2.8	994	674-1531
9	Fulton	Hipple School	6.5	2.0	12.0	10.0-14.0	1.2	0.7-1.5	1162	781-1531
10	Ogle	Forreston	7.4	1.9	13.3	11.0-18.0	0.7	0.5-0.8	1190	995-1516
11	Ogle	Mt. Morris	6.3	2.0	13.5	10.0-17.0	0.9	0.5-1.3	1095	750-1501
12	Stephenson	Cedarville East	6.2	2.0	14.6	13.0-17.5	0.8	0.7-1.0	1049	704-1531
13	St. Clair	River King Mine	6.3	2.0	10.8	9.5-14.0	0.5	0.3-0.6	1005	658-1531
14	Pulaski	Olmsted	7.2	2.0	12.0	10.5-16.0	1.1	0.9-1.3	760	551- 949
15	Wyoming State	Unknown	6.5	2.0	13.5	10.5-16.0	9.3	7.1-13.4	868	536-1133

TABLE 6 - TEST RESULTS OF PELLETS MADE WITH IRON ORE CONCENTRATE AND CLAY FOR SERIES B
(16 pounds of minus-325-mesh clay and 2 pounds of soda ash per ton of iron ore concentrate)

Sample	County	Section	Moisture (%)	Drops to failure	Green strength (oz.)		Dry strength (lbs.)		Fired strength (lbs.)	
					Av.	Extremes	Av.	Extremes	Av.	Extremes
1	Effingham	Funkhouser East	7.9	2.0	16.3	13.5-20.0	3.0	2.0-4.2	1372	1041-1531
2	Montgomery	Panama "A"	4.5	2.1	12.5	8.0-17.0	3.6	2.6-4.4	1426	1133-1531
3	Sangamon	Rochester	5.8	2.2	13.8	10.0-20.5	3.9	3.3-5.7	1207	796-1531
4	Adams	Zion Church	6.4	2.0	10.6	8.5-13.0	4.8	4.0-6.2	1005	582-1363
5	Adams	Lierle Creek	8.3	2.0	16.1	13.0-23.0	5.7	4.2-6.6	1442	1240-1531
6	Adams	Akers School	5.3	2.0	15.3	12.5-18.0	3.4	2.4-4.2	1083	812=1348
7	Pike	Woodland (lower)	5.9	2.0	12.4	10.0-14.5	1.5	1.0-2.0	819	475-1148
8	Pike	Woodland (upper)	8.7	2.0	12.2	11.0-16.0	1.5	1.1-1.9	730	613- 980
9	Fulton	Hipple School	6.8	2.0	12.8	10.0-16.0	3.0	2.0-3.7	1072	689-1531
10	Ogle	Forreston	6.8	2.0	16.8	12.5-21.0	3.9	3.3-4.9	1524	1455-1531
11	Ogle	Mt. Morris	6.4	2.0	13.9	10.0-18.0	2.0	1.3-2.5	986	536-1302
12	Stephenson	Cedarville East	6.3	2.0	12.9	8.0-16.0	1.2	1.0-1.4	1064	582-1531
13	St. Clair	River King Mine	6.4	2.0	12.0	8.0-18.0	0.9	0.8-1.1	986	613-1322
14	Pulaski	Olmsted	6.5	2.0	14.0	12.0-15.5	4.8	4.0-6.0	848	674-1072
15	Wyoming State	Unknown	7.4	2.7	16.7	14.5-21.0	9.4	8.4-11.0	1144	766-1531

TABLE 7 - TEST RESULTS OF PELLETS MADE WITH IRON ORE CONCENTRATE AND CLAY FOR SERIES C
(16 pounds of minus-20-micron clay per ton of iron ore concentrate)

Sample	County	Section	Moisture (%)	Drops to failure	Green strength (oz.)		Dry strength (lbs.)		Fired strength (lbs.)	
					Av.	Extremes	Av.	Extremes	Av.	Extremes
1	Effingham	Funkhouser East	6.7	2.0	16.1	13.5-20.0	2.4	1.8-3.0	1433	1225-1531
2	Montgomery	Panama "A"	6.3	2.0	15.9	12.0-20.0	2.4	2.1-2.6	1479	1225-1531
3	Sangamon	Rochester	5.8	2.0	13.3	11.0-16.5	1.3	0.8-1.9	1343	980-1531
4	Adams	Zion Church	6.5	2.0	13.9	11.5-17.0	3.2	2.4-4.4	1213	781-1531
5	Adams	Lierle Creek	5.8	2.0	10.1	8.0-13.0	2.1	1.3-2.9	1231	1057-1439
6	Adams	Akers School	5.3	1.7	9.9	7.0-13.0	2.7	2.5-3.0	1044	735-1531
7	Pike	Woodland (lower)	7.2	1.8	10.8	7.0-15.0	2.2	2.1-2.4	905	383-1348
8	Pike	Woodland (upper)	7.1	2.0	12.5	10.0-15.0	2.4	1.8-3.5	1012	643-1501
9	Fulton	Hipple School	6.4	2.0	14.3	11.0-17.0	1.0	0.7-1.6	1041	643-1302
10	Ogle	Forreston	6.3	1.9	14.7	11.0-18.5	3.6	2.4-4.4	1311	919-1531
11	Ogle	Mt. Morris	6.1	1.9	13.8	10.0-18.0	1.0	0.8-1.1	1276	613-1531
12	Stephenson	Cedarville East	6.2	2.0	13.9	11.0-17.5	0.7	0.6-0.8	1040	750-1531
13	St. Clair	River King Mine	6.0	2.0	12.3	10.5-17.0	0.8	0.5-1.2	784	582-1118
14	Pulaski	Olmsted	6.5	2.1	11.3	8.0-15.0	1.9	1.1-2.2	905	628-1225
15	Wyoming State	Unknown	7.0	2.4	11.8	8.5-15.0	8.0	6.4-9.7	681	475- 980

The amount of water varied because the individual clays had different absorbencies. After the pellets were formed they were left in the wheel for about 2 minutes so that they would be compacted into spherical units. This time factor approximates that used in pelletizing plants. The pellets were removed from the wheel and screened; subsequent tests for strength were conducted on the minus three-eighths inch and plus one-fourth inch fraction only to make comparisons meaningful.

Ten pellets from each clay sample were subjected to the drop test, in which the pellets are repeatedly dropped 18 inches onto a steel platform until they fail. The number of drops is indicative of strength. Unfortunately, this laboratory test was quite inconclusive as almost all of the pellets failed at the same point. Ten more pellets from each clay sample were tested for green strength. This involves applying a force at a uniform rate to each pellet before it is dried. The force required to crush the pellets was recorded for each and the strength for each series averaged.

The remaining pellets were weighed, dried at 392° F (200° C) for 30 minutes, and weighed again. Moisture content of the pellets was determined as follows:

$$\frac{\text{wet weight} - \text{dry weight}}{\text{wet weight}} \times 100 = \% \text{ moisture.}$$

Ten dry pellets from each clay sample were tested for dry strength by a procedure similar to that used for the green strength tests. The remaining dry pellets were fired at 2400° F (1315° C) for one hour, permitted to cool slowly to 1450° F (790° C), and cooling was finished at room temperature. Ten of the fired pellets from each sample were tested on a modified dynamic load tester, which involved pressure to failure. Tables 5, 6, and 7 show the results of these tests.

FREE SILICA TESTS

The quantity of cristobalite contained in clays is of universal concern. Cristobalite is a form of silica that is particularly hazardous as a cause of silicosis. While the Illinois clays, with one exception, have high silica contents, X-ray analysis showed no cristobalite in any of them. Table 8 shows the free silica content of the clays tested.

CONCLUSIONS

At least seven of the Illinois clays tested display strength that might make them good substitutes for western bentonites as binders for iron ore pellets.

The addition of small quantities of soda ash is required for satisfactory dry strength in pellets made with Illinois clays. Soda ash makes little difference in the development of the green or fired strength.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE 8 - FREE SILICA DETERMINATION IN MINUS-20-MICRON FRACTION OF CLAY

Sample	County	Section	% Free silica
1	Effingham	Funkhouser East	43.03
2	Montgomery	Panama "A"	29.38
3	Sangamon	Rochester	36.63
4	Adams	Zion Church	31.69
5	Adams	Lierle Creek	31.05
6	Adams	Akers School	35.90
7	Pike	Woodland (lower)	51.97
8	Pike	Woodland (upper)	41.99
9	Fulton	Hipple School	31.00
10	Ogle	Forreston	43.36
11	Ogle	Mt. Morris	35.76
12	Stephenson	Cedarville East	39.89
13	St. Clair	River King Mine	23.09
14	Pulaski	Olmsted	0.56
15	Wyoming State	Unknown	1.10

The fired strength of most of the pellets made with Illinois clay was higher than that made with western bentonite. Any fired strength higher than 500 pounds is satisfactory for handling and shipping.

No cristobalite was found in the Illinois clays during X-ray analysis.

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*Out of print